United States Patent [19] [11] **4,368,838**
Sheffield et al. [45] **Jan. 18, 1983**

[54] **BLIND RIVETING MACHINE**

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[73] Assignee: **Aerpat A.G.**, Zug, Switzerland

[21] Appl. No.: **160,195**

[22] Filed: **Jun. 17, 1980**

[30] **Foreign Application Priority Data**

Jun. 20, 1979 [GB] United Kingdom 7921486

[51] **Int. Cl.**³ **B21J 15/34**
[52] **U.S. Cl.** **227/55**; 29/243.53; 72/391
[58] **Field of Search** 29/243.53; 72/391; 227/55, 57, 120

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,557,597	1/1971	Heslop et al.	72/391
3,828,603	8/1974	Sheffield et al.	72/391
3,832,880	9/1974	Charman	72/391
3,892,120	7/1975	Sheffield et al.	72/391

FOREIGN PATENT DOCUMENTS

2225439 12/1972 Fed. Rep. of Germany 72/391

Primary Examiner—Paul A. Bell
Attorney, Agent, or Firm—Oblon, Fisher, Spivak, McClelland & Maier

[57] **ABSTRACT**

In a blind riveting machine, in which a mandrel having a head is pulled downwardly by reciprocable and openable pulling jaws to draw the mandrel head through the bore of a tubular rivet supported at a setting station by normally closed, openable nose jaws, the nose jaws have yieldable detent means for resisting upward movement of the mandrel, and a reciprocable tube concentric with the mandrel for lifting further rivets along the mandrel, past the opened pulling jaws and nose jaws, to the setting station, has a spring detent which becomes frictionally engaged with the mandrel whereby the mandrel after being lifted with the rivets can be pulled downwardly again so that its head abuts the rivet at the setting station, thereby accurately adjusting the position of the mandrel relative to the pulling jaws, before the pulling jaws again grip the mandrel, in dependence upon the actual size of the rivet next to be set.

10 Claims, 8 Drawing Figures

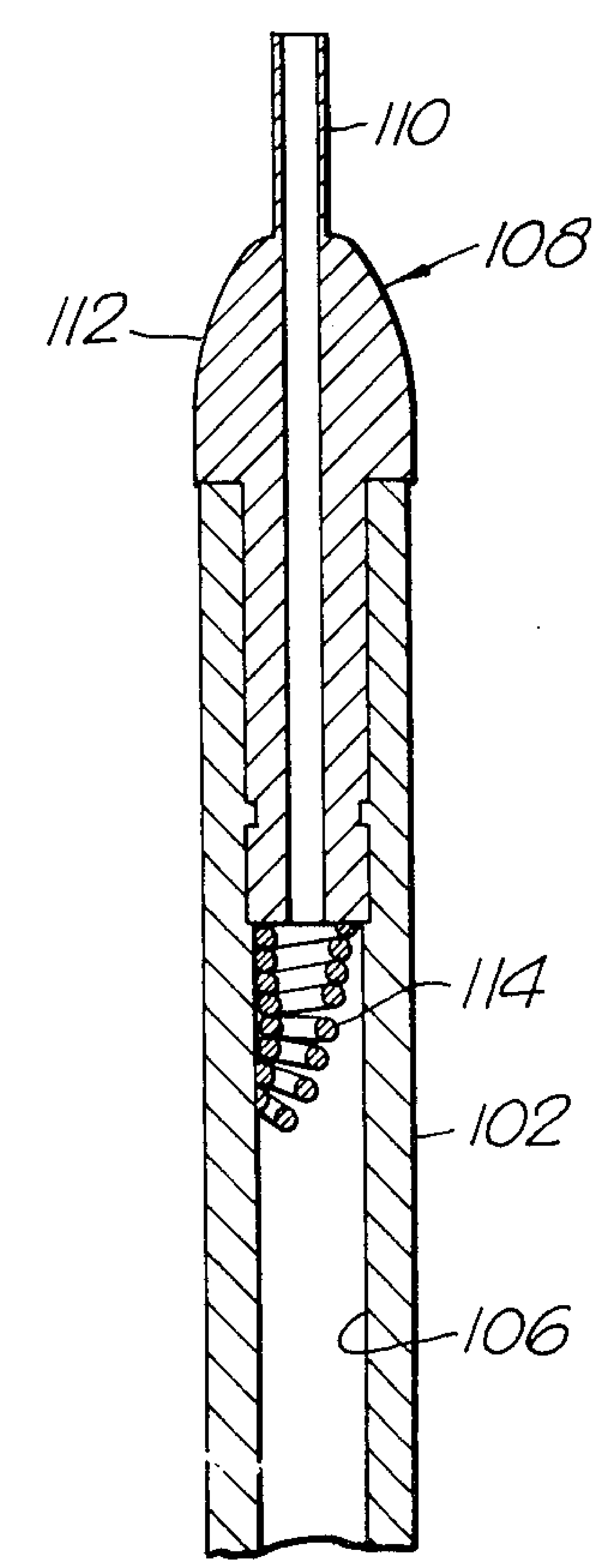
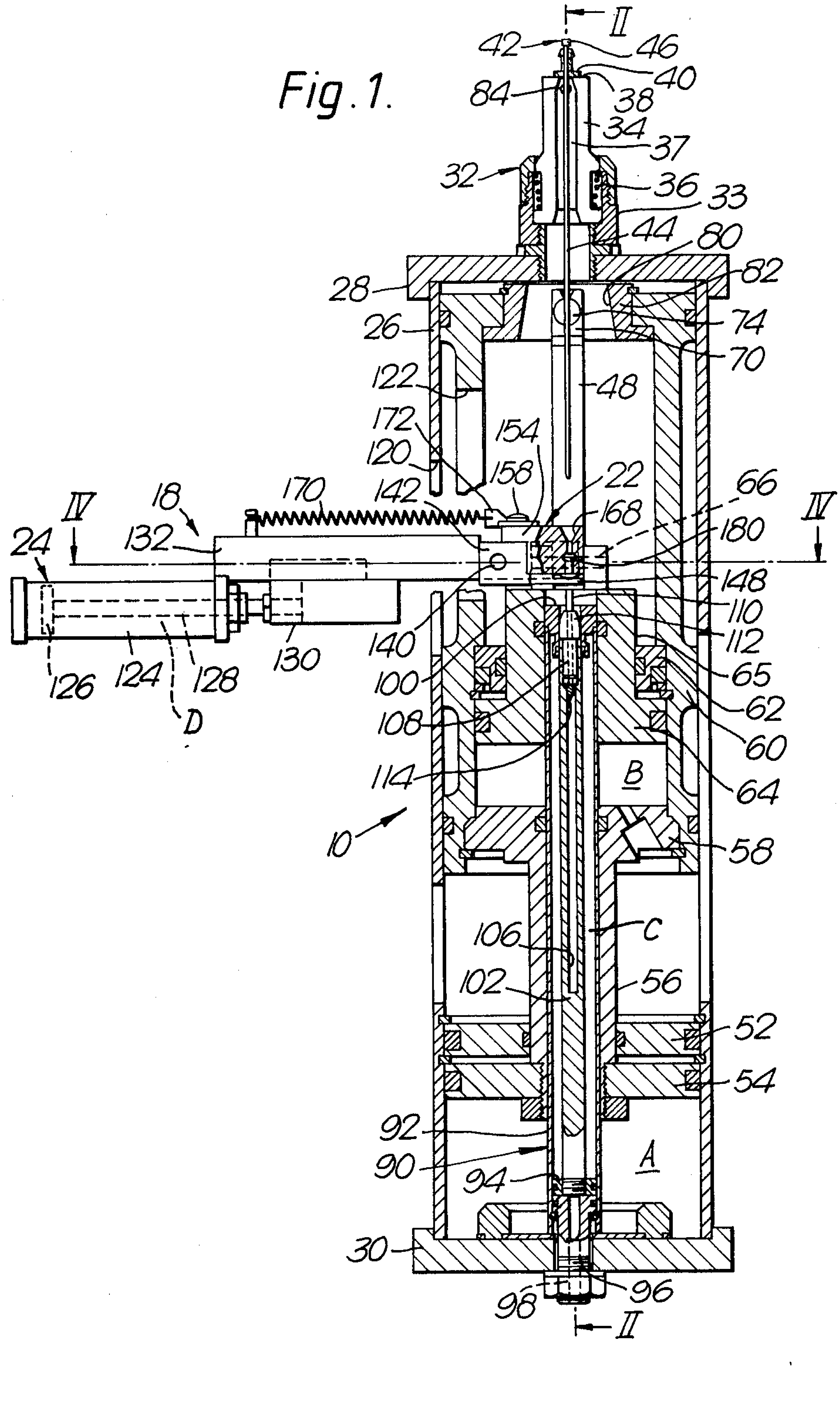


Fig. 1.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IV
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148
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112
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65
100
62
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D
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114
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98
II

Fig. 2.

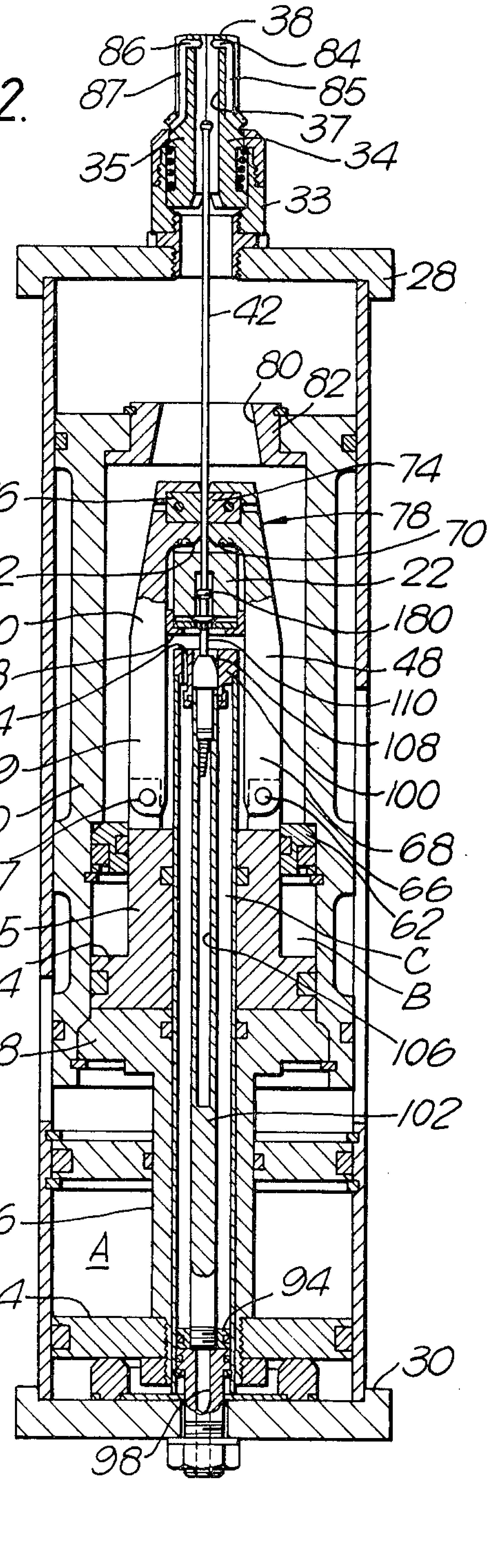
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Fig. 3.

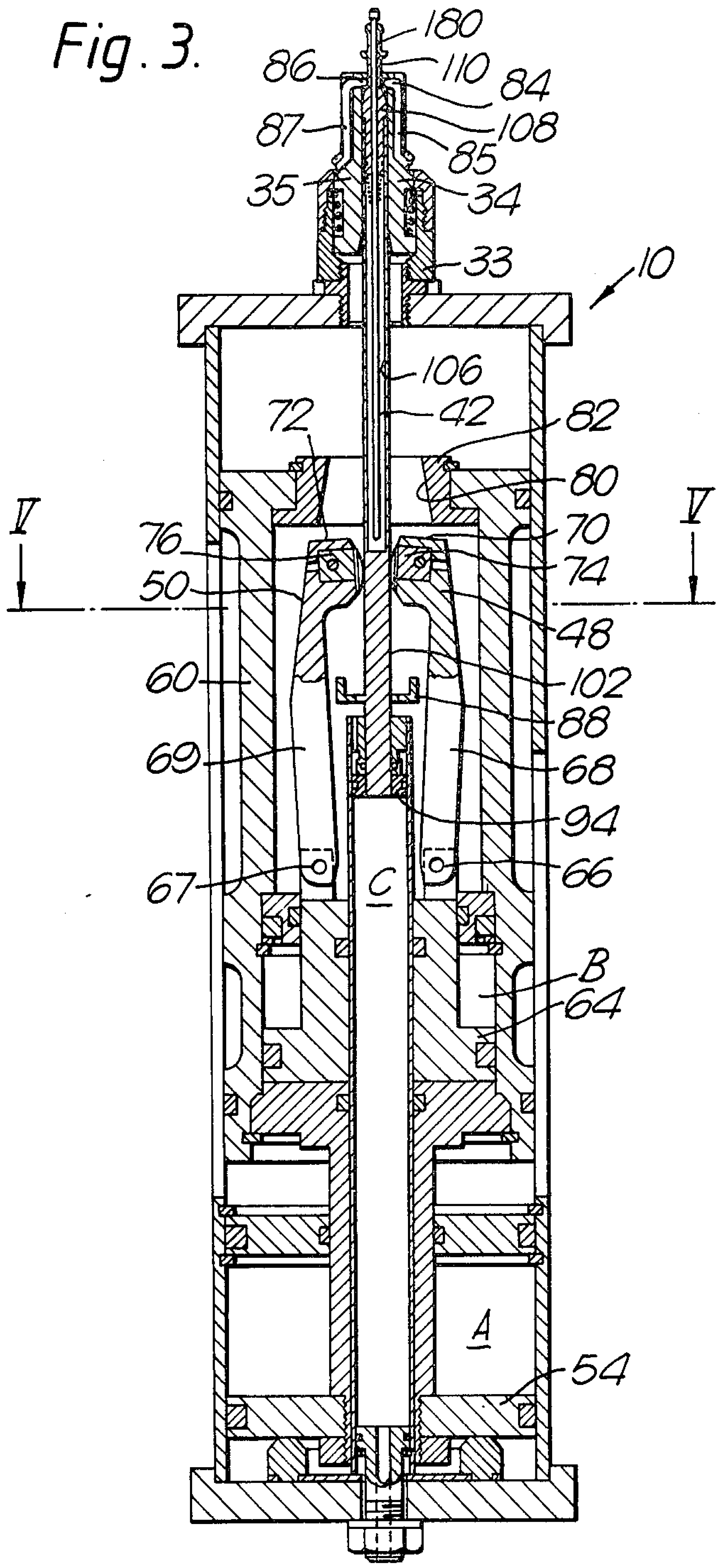
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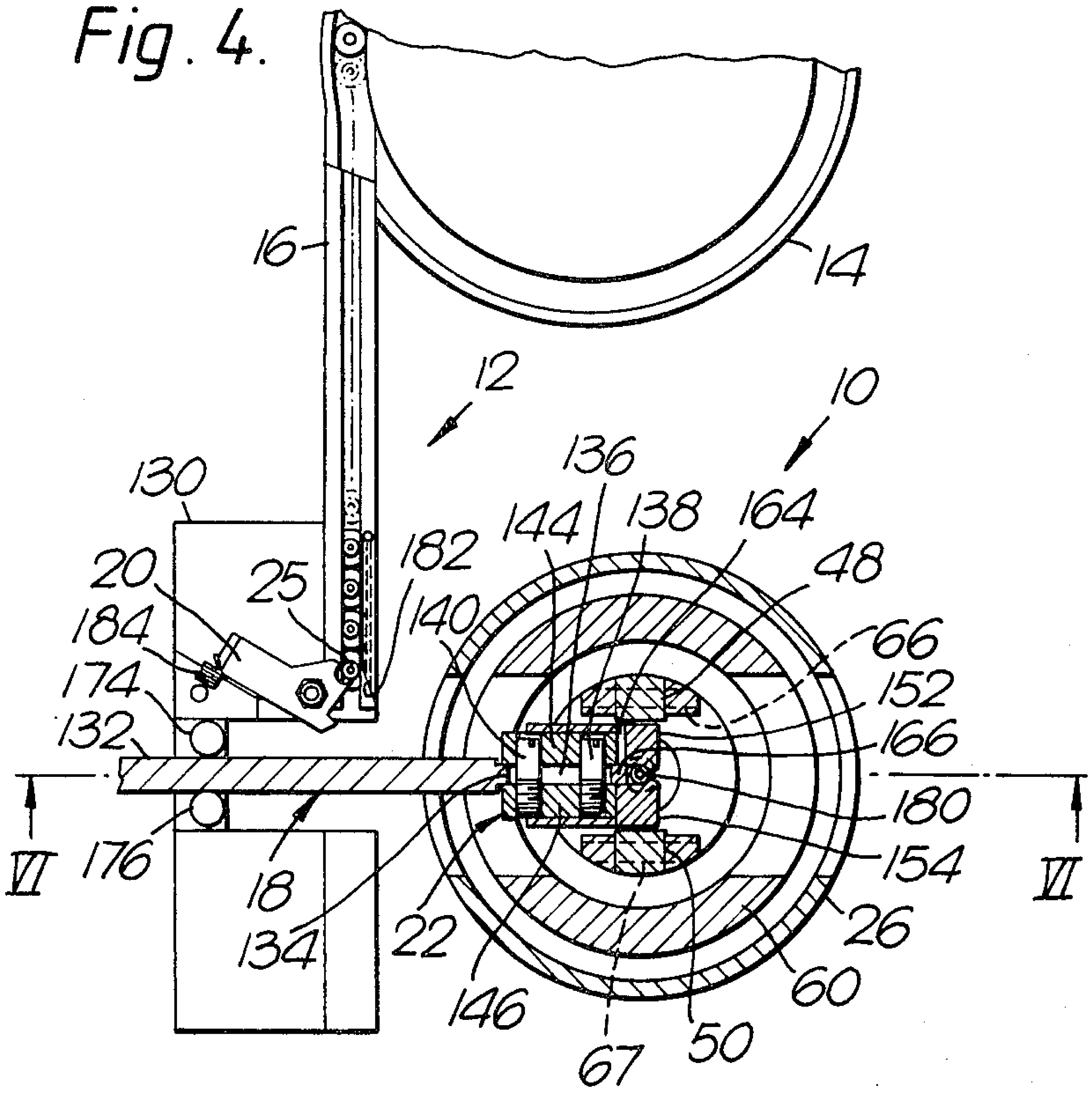
Fig. 4.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VI
176
18
134
22
146
26
60
67
50
VI

Fig. 5.

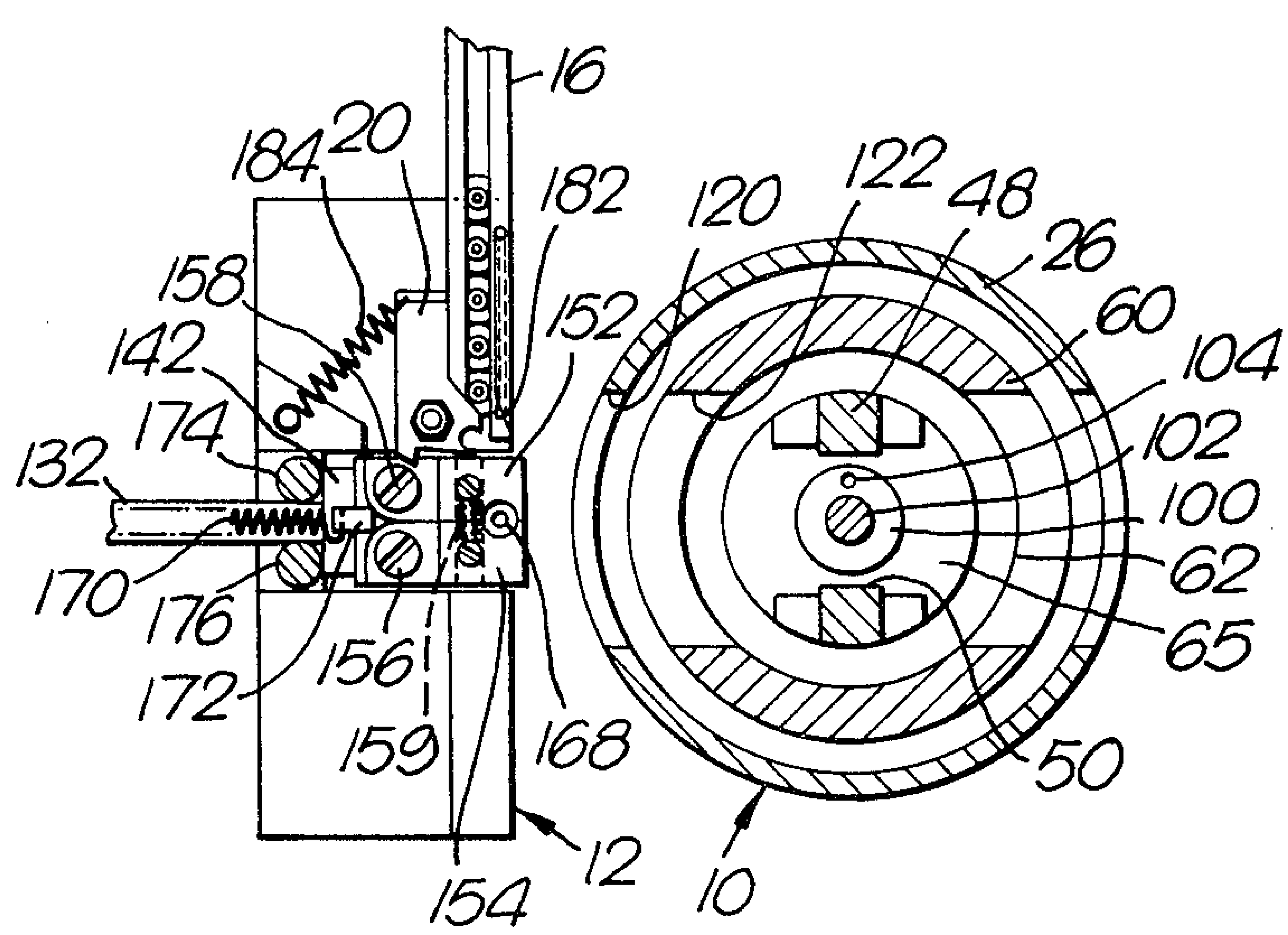
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Fig. 6.

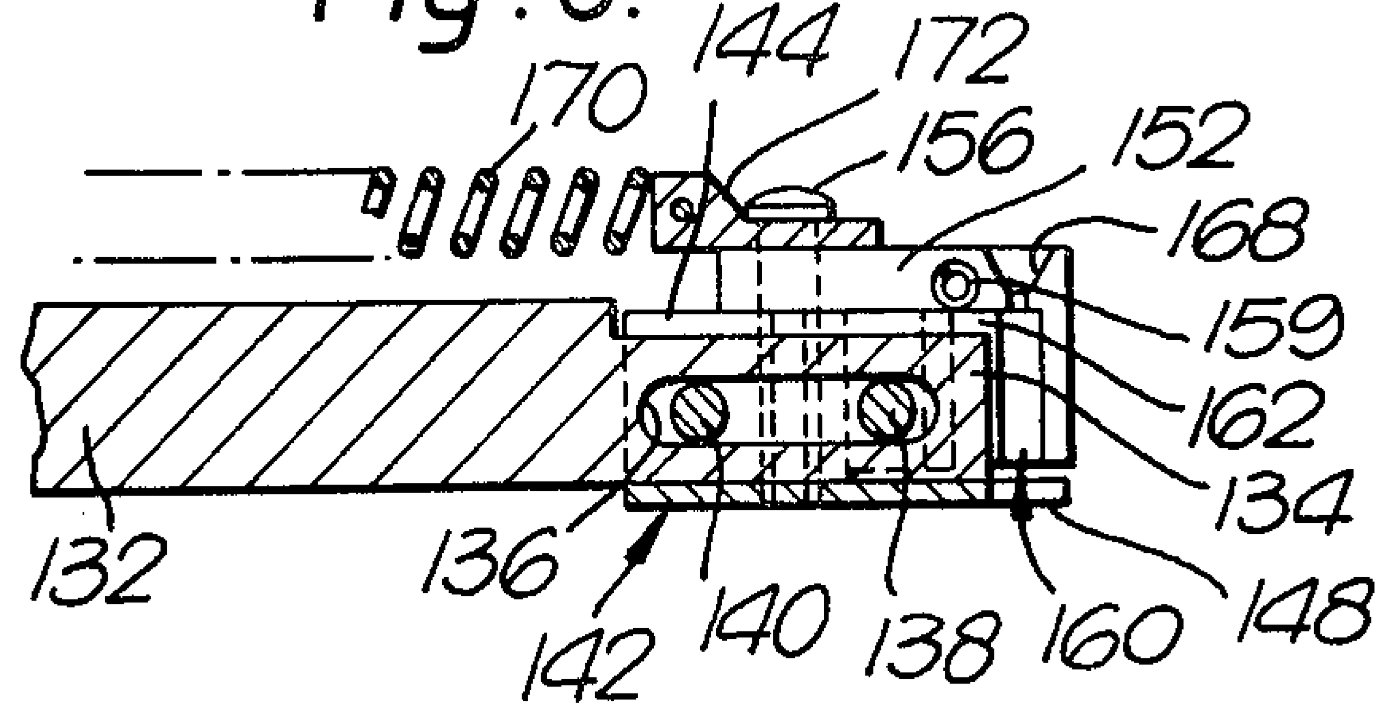
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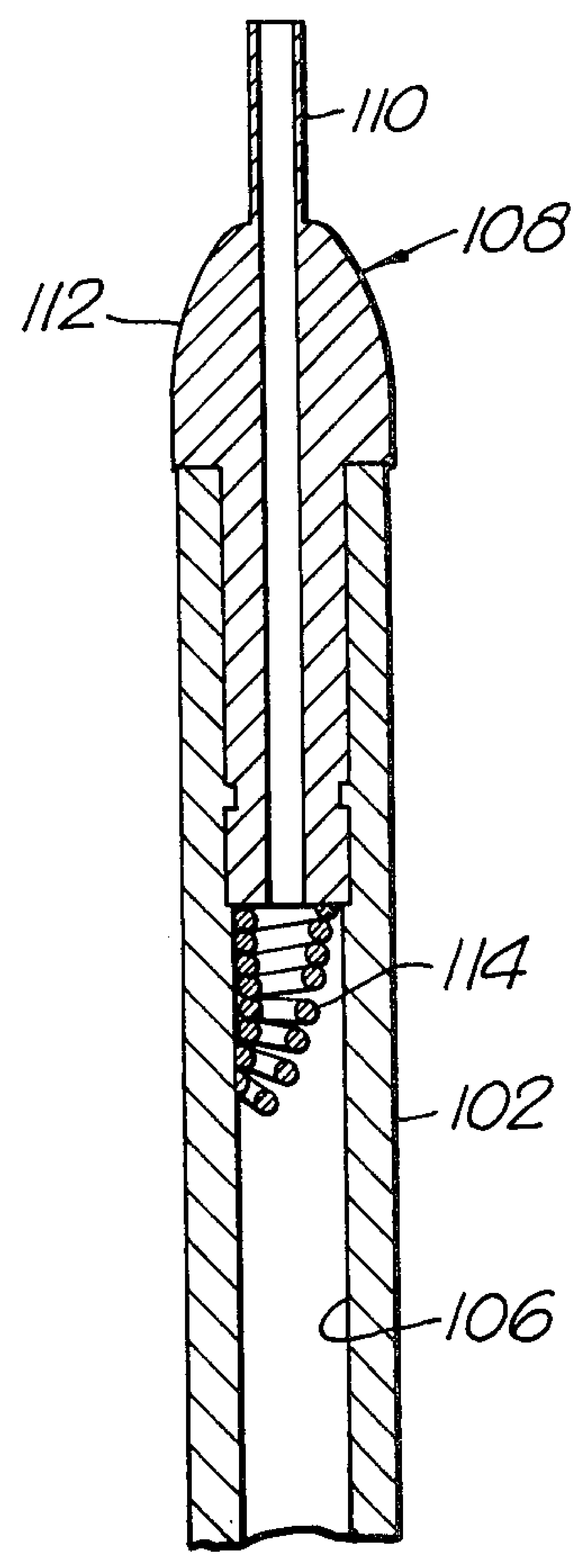
Fig. 8.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102
106

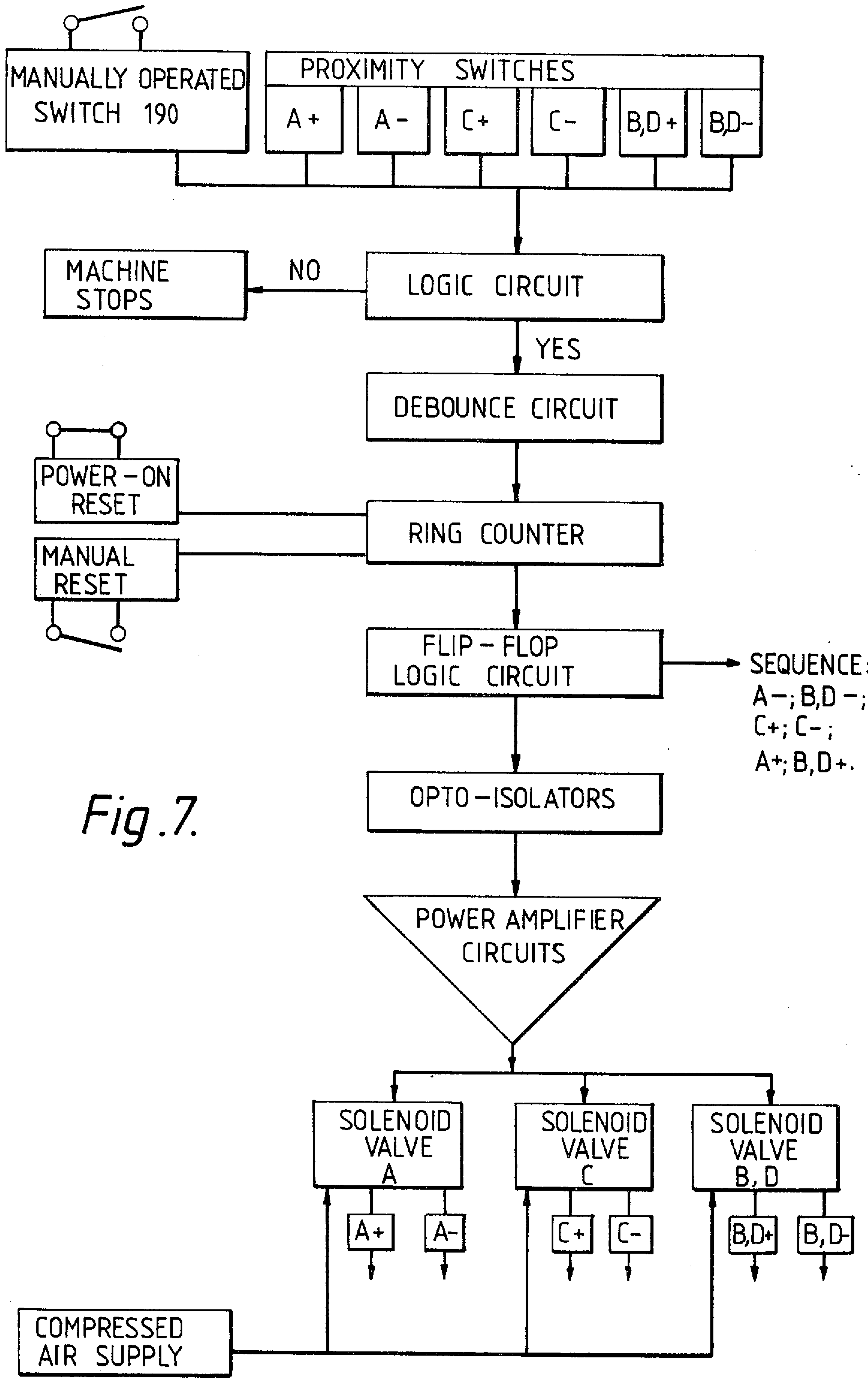
MANUALLY OPERATED SWITCH 190
PROXIMITY SWITCHES
A+
A-
C+
C-
B,D+
B,D-
MACHINE STOPS
NO
LOGIC CIRCUIT
YES
DEBOUNCE CIRCUIT
POWER-ON RESET
MANUAL RESET
RING COUNTER
FLIP-FLOP LOGIC CIRCUIT
SEQUENCE:
A-; B,D-;
C+; C-;
A+; B,D+.
OPTO-ISOLATORS
POWER AMPLIFIER CIRCUITS
SOLENOID VALVE A
SOLENOID VALVE C
SOLENOID VALVE B, D
A+
A-
C+
C-
B,D+
B,D-
COMPRESSED AIR SUPPLY

Fig. 7.

BLIND RIVETING MACHINE

This invention relates to a riveting machine for setting blind tubular rivets. More particularly it relates to a machine of the kind in which tubular rivets supported at a setting station by an abutment means are set by pulling through successive rivets an enlarged head of a mandrel, and in which after the setting of each rivet, a further rivet is automatically presented at the setting station.

The riveting machine of the invention is intended for setting blind tubular rivets of the kind comprising a shank and an enlarged head at one end of the shank, and having a bore extending through the head and shank. Such rivets are well known and are commercially available under the registered Trade Marks "Chobert" and "Briv". Such rivets are set by means of an elongate mandrel which is moved lengthwise relative to an abutment which supports the rivets, the mandrel having a stem on which the rivets are a sliding fit and an enlarged head at one end of the stem, each rivet being threaded onto the mandrel stem with the tail end of the rivet (i.e. the end of the rivet shank remote from the rivet head) towards the head of the mandrel, and the mandrel and the rivet supporting abutment are then relatively moved, by, for example, pulling the mandrel so as to draw the mandrel head through the rivet bore while the rivet is supported by the abutment, thereby expanding the shank of the rivet.

In known machines of the kind referred to it is necessary to set the machine up in such a way that, when the machine is ready to set a rivet at the setting station, the mandrel occupies a predetermined position relative to the abutment means. This position is determined primarily in accordance with the known nominal length of the rivets to be set, but regard must, of course, also be paid to any limitation imposed by the depth of blind holes in which the rivets are to be set and the length of stroke through which the mandrel can be pulled. Having set the machine for rivets of a particular length, its operation may then be unsatisfactory if supplied with rivets of a different length such as may happen either intentionally or unintentionally, for example if the supply of rivets is contaminated with rivets of a different length, or due to manufacturing tolerances introducing variations from the known nominal length. Furthermore it is important to reset the machine whenever the nominal length of the rivets is changed.

In U.S. Pat. No. 3,832,880 there is described such a machine in which a pair of pulling jaws are power operated to grip and reciprocate the mandrel and also to open, releasing the mandrel, while further rivets are fed along the mandrel towards its head, and a pair of nose jaws are power operated to close and grip the mandrel so as, on the one hand, to support it while the pulling jaws are open and, on the other hand, to provide an abutment for supporting a rivet while the rivet is set by pulling the mandrel head through its bore, the nose jaws being power operated to open, releasing the mandrel at a time when it is held by the pulling jaws, so as to allow a further rivet to pass between the nose jaws towards the head of the mandrel. Thus the mandrel is always gripped by either the pulling jaws or the nose jaws and, once the machine has been set up, the positional relationship of the mandrel to the nose jaws remains constant.

In another prior riveting machine of the general kind referred to, and which is described in U.S. Pat. No. 3,557,597 (Heslop), a long mandrel loaded with a plurality of rivets is clamped into the body of the machine by a chuck which grips the end of the mandrel remote from the mandrel head, and the body of the machine reciprocates relative to the abutment means so that the mandrel is alternately pulled rearwardly and returned forwardly relative to the abutment means. A cursor is provided for progressively advancing the plurality of rivets along the mandrel so that as one rivet is set, the next rivet nearest the mandrel head is advanced to the setting station.

In the latter machine, the mandrel has to be removed in order to load it with further rivets, and when reloaded is clamped into the body of the machine again so that its position in relation to the abutment means is fixed for the particular load of rivets, and there is no way in which the position of the mandrel can be adjusted to compensate for variations in length as between individual rivets.

In all the prior riveting machines of which we are aware, the positional relationship of the pulling jaws relative to the abutment means remains fixed and the positional relationship of the mandrel relative to the abutment means remains constant through successive rivet setting operations. Consequently, any variation in length as between one rivet and the next has usually required resetting of the machine or has led either to unsatisfactory performance of the machine or the need to allow large tolerances which can be detrimental to satisfactory riveting operations. We have now found that a riveting machine can be made to set rivets of various lengths without the need to reset the machine for each individual length, by providing means for automatically adjusting the position of the mandrel relative to the abutment means in accordance with the length of every individual rivet next to be set.

According to the present invention there is provided a blind riveting machine comprising abutment means for supporting a rivet during a rivet-setting operation, a mandrel having a stem and an enlarged head at one end of the stem, gripping and pulling means for releasably gripping the stem of the mandrel and moving the mandrel rearwardly relative to the abutment means through a stroke of sufficient length to pull the head of the mandrel entirely through the bore of a tubular rivet supported by the abutment means and thereby set the rivet and thereafter to release the mandrel to allow a further rivet to pass along the stem of the mandrel towards the head, and means for adjusting the position of the mandrel after the setting of a rivet and the release of the mandrel and before the gripping and pulling means again grips the mandrel stem, so that the mandrel is moved to a position in which the head is spaced forwardly of the abutment means by a distance which is at least sufficient to accommodate a further rivet to be set and which does not exceed the length of stroke of the gripping and pulling means.

The means for adjusting the position of the mandrel may comprise a reciprocable member arranged to move the mandrel forwardly after the setting of a rivet and, if necessary, to then move the mandrel rearwardly so that the head of the mandrel is spaced forwardly of the abutment means by the aforesaid distance.

The reciprocable member may include a detent means for frictionally engaging the mandrel so that the mandrel can be moved with and by the reciprocable member, the detent means being capable of being overridden by abutment of the mandrel head with a rivet supported by the abutment means.

The detent means may comprise a resiliently deformable means adapted and arranged to frictionally hold the mandrel when the mandrel and the detent means are forced into mutual engagement.

The detent means may comprise a tube formed of resiliently deformable material and having a curved axis. The tube may be formed of helically wound wire.

The machine may include yieldable means for resisting forward movement of the mandrel so as to cause the mandrel to be urged into frictional engagement with the detent means.

The yieldable means may comprise one or more yieldable detents arranged to resist passage of the head of the mandrel from a position rearwardly of the abutment means to a position forwardly of the abutment means.

The abutment means may be provided by separable nose jaws which house the yieldable detents.

An embodiment of the invention will now be described by way of example with reference to the accompanying drawings, in which:

FIG. **1** is an elevation, mainly in section, from the front of a blind riveting machine showing the positions of the principal parts in a condition ready to set a rivet;

FIGS. **2** and **3** are sectional elevations, on the line II—II in a plane at right angles to that of FIG. **1**, showing the positions of the principal parts in two successive stages of operation after the setting of a rivet;

FIG. **4** is a section on the line IV—IV of FIG. **1**;

FIG. **5** is a section on the line V—V of FIG. **3**;

FIG. **6** is an enlarged fragmentary section on the line VI—VI of FIG. **4**;

FIG. **7** is a schematic block diagram illustrating electrical and pneumatic means for causing controlled operation of the machine, and

FIG. **8** is a vertical section on an enlarged scale of a part of a reciprocable member of the machine, having spring detent means.

The machine of the illustrated embodiment is a bench-mounted machine adapted to maintain a supply of rivets and automatically to thread the rivets onto a mandrel, to deliver them to a rivet setting station and to set the rivets in a suitable apertured workpiece at the setting station from below the workpiece. Thus, successive rivets are presented singly at the setting station, head down and tail uppermost with the shank extending vertically upwards, the workpiece being positioned so that the tail of a rivet at the setting station projects through an aperture in the workpiece, and the rivet is then set. A further rivet is then automatically presented at the setting station ready for setting.

The general organization and operation of the machine will now be described.

The riveting machine comprises a riveting head **10**, together with rivet supply means **12** for supplying rivets to the riveting head, and control means for controlling the operation of the machine.

The rivet supply means **12** comprises an electrically operated vibratory bowl feeder **14** of conventional construction, a flight **16** and a transfer means **18**. The bowl feeder is employed to contain a supply of tubular rivets and continually to orientate and feed the rivets to the flight. The orientated rivets pass along the flight to the transfer means. The egress of the rivets from the end of the flight remote from the bowl feeder is controlled by an escapement **20** operated by the reciprocatory movement of a rivet carrier **22** forming part of the transfer means **18**.

The rivet carrier **22** is reciprocated in a horizontal direction by controlled operation of a double-acting pneumatic jack **24**. Retraction of the rivet carrier **22** (i.e. movement to the left from the position shown in FIGS. **1** and **4**) brings the rivet carrier into line with the flight and operates the escapement to allow a leading rivet **25**, shown in FIG. **4**, to leave the flight and enter the rivet carrier. Subsequent operation of the jack **24** causes the rivet carrier **22** to carry the rivet away from the flight and to a waiting position within the riveting head **10**, as shown in FIG. **1**, where it waits for induction of the rivet into the riveting head.

The riveting head **10** comprises a housing **26** in the form of a hollow cylinder mounted with its axis vertical and substantially closed at its upper and lower ends by end plates **28**, **30** respectively. The upper end plate **28** has a central aperture in which is threadedly engaged a riveting nose **32**. The riveting nose comprises a generally tubular body **33**, threaded at its lower end for engagement with the end plate **28**, and in which are housed a pair of nose jaws **34**, **35** (see FIG. **2**) and a compressed helical jaw-closing spring **36**.

The nose jaws are of generally semi-cylindrical shape, and are disposed on diametrically opposite sides of the axis of the cylindrical housing where they are able to co-operate with each other to form a tube having a vertical axial passageway **37** which is flared adjacent to its lower end and, adjacent to its upper end, is reduced in diameter through a taper to a constricted upper portion. The spring **36** urges the jaws downwardly into the body **33** so that the jaws are constrained to a closed condition in which their upper ends co-operate to form an annular abutment **38** whereby a rivet **40** to be set by the machine is supported at a setting station immediately above the nose jaws, as shown in FIG. **1**.

The riveting head includes a mandrel **42** having an elongate stem **44** able to pass with clearance through the bore of each tubular rivet to be set, and an enlarged head **46** which will expand the shank of each rivet when pulled into its bore. The mandrel **42** is aligned with and reciprocable along the axis of the housing **26** and, in the condition shown in FIG. **1** in which the machine is ready to set the rivet **40**, the mandrel is supported by its head resting on the upper end of the rivet **40** at the setting station while its stem **44** depends from the head **46** and extends downwardly, through the bore of the rivet **40** and the passageway **37** formed by the co-operating closed nose jaws, to a position just above the rivet carrier **22** and the waiting station.

The diameter of the passageway **37**, except in the constricted upper portion, is just sufficient for a rivet to pass along the passageway. The diameter of the constricted upper portion of the passageway is of slightly greater diameter than the head of the mandrel so that the mandrel head can pass through the constricted upper portion and enter the passageway when the nose jaws are closed.

The nose jaws can be forced to move upwardly relative to the body **33**, causing resilient compression of the spring **36**, and their upper ends can then be separated sufficiently to allow a further rivet to move upwardly through the constricted upper portion of the passageway. This is achieved during use of the machine by forcing a further rivet upwardly through the passageway until the rivet reaches the taper leading to the constricted upper portion of the passageway, whereupon the nose jaws are lifted by the further rivet until the body **33** no longer constrains the upper ends of the nose jaws to remain closed. The further rivet can then urge the upper ends of the nose jaws to separate and can pass upwardly to the setting station above the nose jaws. Once the rivet has passed beyond the jaws, the spring **36** is able to return the nose jaws downwardly into the body **33** so that they are again constrained into the closed condition and their upper ends thus close beneath the further rivet, forming again the annular abutment **38** to support the further rivet.

Each of the nose jaws **34**, **35** of the riveting nose **32** is provided with a detent **84**, **86** respectively which projects through an opening in the jaw and into the passageway **37** in the region of the constricted upper portion. The detents **84**, **86** are disposed on diametrically opposite sides of the passageway in opposed relation to each other and are resiliently urged inwardly of the passageway **37**, towards each other and the mandrel between them, by biasing springs **85**, **87** respectively. In this embodiment, each detent is formed integrally with its respective biasing spring from a single piece of spring steel wire which is bent so as to have at one end, a circular eye through which a screw extends into threaded engagement with the nose jaw so as to secure the detent and its biasing spring to the external surface of the nose jaw. The biassing spring extends from the screw and eye upwardly along a groove in the external surface of the jaw to the opening in the jaw, and the detent at the other end of the wire extends substantially at right angles to the biasing spring and through the opening so as to project into the taper leading to the constricted upper portion of the passageway **37**.

In this embodiment the detents **84**, **86** frictionally engage the mandrel stem between them and offer some resistance to longitudinal movement of the mandrel stem between them. Particularly important is the fact that, when the nose jaws are closed, the detents project inwardly sufficiently far to present a substantial resistance to axial movement of the enlarged head of the mandrel past the detents, especially in the upward direction of movement of the mandrel. The reasons for these requirements will become apparent when the operation of the machine is discussed.

Within the housing **26** is disposed pulling means whereby the mandrel can be pulled downwardly relative to the nose jaws from the position shown in FIG. **1** so that the mandrel head is drawn through the bore of the rivet **40**, thereby expanding and setting the rivet. The pulling means comprises a pair of pulling jaws **48**, **50** of which only jaw **48** is visible in the view shown in FIG. **1**, and includes means for urging the pulling jaws into tightly gripping relationship with the stem of the mandrel and means for reciprocating the pulling jaws vertically within the housing. The pulling means is operated pneumatically and, to this end, includes a pneumatic pulling chamber A and a pneumatic jaw-closing chamber B.

The pulling chamber A is defined within the lower end of the cylindrical housing **26** between the lower end plate **30** and an annular seal **52** fixedly secured within the housing at a position spaced above the lower end plate **30**. The upper and lower ends of the chamber A are provided with ports (not shown) for the admission of compressed air, and within the chamber A is disposed an annular pneumatic piston **54**. Secured to the piston **54** is an annular piston rod **56** which carries an assembly of parts all of which move with the piston **54** when the latter reciprocates in chamber A. The piston rod **56** is slideable in pneumatically sealed relationship through the annular seal **52** and is radially expanded at its upper end in the form of a flange **58** which not only forms a lower end closure for the jaw-closing chamber B but also supports a generally cylindrical head member **60** which extends upwardly from the flange **58** and forms a sliding fit with the internal surface of the cylindrical housing **26**. The head member **60** is generally tubular and, together with the flange **58** and an annular seal **62**, defines the chamber B in which an annular piston **64** is vertically reciprocable. The flange **58** and the seal **62** are each provided with a port for the admission of compressed air into the chamber B below and above the piston **64** respectively.

Integral with the piston **64** is a piston rod **65** which extends upwardly from the piston and through the annular seal **62**. The upper end of the piston rod **65** carries two spaced parallel pivots **66**, **67** on which are pivotally mounted the pulling jaws **48**, **50** respectively. The pulling jaws **48**, **50** are elongate structures having legs **68**, **69** respectively which extend substantially vertically upwardly, in spaced relationship, from their respective pivots **66**, **67**, and are formed at their upper ends with mandrel-gripping portions **70**, **72** which extend inwardly towards each other so as to form a vertically elongate covered archway between them. The mandrel gripping portions are provided with mandrel gripping teeth **74**, and **76** respectively in the form of hardened steel inserts. The pulling jaws are spring biased to pivot so that their mandrel gripping portions are resiliently urged towards a closed position in which the teeth engage the stem of the mandrel **42**.

A U-shaped yoke **88**, comprising a transverse web and two spacing limbs at the ends of the web, is secured to the body of the machine so that the spacing limbs extend into the archway between the legs of the pulling jaws. The spacing limbs of the yoke serve to centralise the pulling jaws about the axis of the mandrel in the machine, each limb preventing the adjacent pulling jaw from being moved pivotally beyond the mandrel axis by the spring bias applied to it. Furthermore, when the rivet carrier **22** moves into the waiting position it enters between the limbs of the yoke and is positively guided by them into a position in which a fed rivet in the carrier is accurately aligned with the mandrel axis.

The spring bias applied to the pulling jaws is not sufficient to cause the jaws to grip the mandrel stem but only to engage it with light pressure. In order that the pulling jaws may grip the mandrel with sufficient force to enable the mandrel to be pulled so as to set a rivet, the upper end portions of the two pulling jaws are shaped so as to co-operate together, when closed, to form diametrically opposite halves of an upwardly tapering truncated cone **78** which can enter into wedging engagement with an upwardly tapered conical aperture **80** formed in a hard steel annular member **82** secured at the upper end of the cylindrical head member **60**. The arrangement is such that when the piston **64** moves towards the upper end of the jaw closing chamber B, the cone **78** formed by the co-operating pulling jaws is forced into the tapered aperture **80**, and the jaws are thereby constrained to close tightly together, gripping the mandrel between them. Conversely, when the piston **65** moves towards the lower end of the jaw-closing chamber B, the jaws are withdrawn from the tapered aperture **80** so that they are no longer held in tightly closed relationship but, nevertheless, are still resiliently spring biased towards the closed position so that the cone **78** of the pulling jaws will again be able to enter the tapered aperture **80** when the piston **64** rises in chamber B. It will be appreciated, therefore, that the teeth **74, 76** of the pulling jaws are maintained in light frictional engagement with the mandrel stem **44**. If for any reason the mandrel is removed from the machine, the spacing limbs of the yoke **88** maintain the pulling jaws in a central position so that a mandrel can easily be inserted between them again.

As previously mentioned, the pistons **54** and **64** and their associated piston rods **56, 65** are annular. Together, they define a tube which is co-axial with the cylindrical housing **26**, and within the tube is disposed a double-acting pneumatic lifting jack **90**. The jack **90** comprises a cylinder **92** and a piston **94** which is vertically reciprocable in a chamber C within the cylinder **92**. The lower end of the cylinder **92** is secured to the lower end plate **30** and is substantially closed by a plug **96** having an axial port **98** for admission of compressed air in to the chamber C below the piston **94**. The upper end of the cylinder **92** is provided with an annular seal **100** through which extends a piston rod **102**, the lower end of which is attached to the piston **94**. The seal **100** is provided with an eccentrically positioned port **104** for admission of compressed air into the chamber C above the piston **94**.

The piston rod **102** is slideable in pneumatically sealed relationship through the annular seal **100** and is formed with a stopped axial bore **106** which opens at the upper end of the piston rod. A tubular nosepiece **108** is retained in the upper end of the stopped bore **106** and provides a tubular extension of the piston rod **102** in the form of an upwardly tapering, generally frusto-conical deflector **112** which is seated upon the upper end of the piston rod **102**, and a cursor tube **110** which projects vertically upwards from the deflector. The cursor tube **110** has an internal bore of a diameter adequate to receive the stem **44** of the mandrel **42** with slight clearance, and the combined lengths of the stopped bore **106** and the extension provided by the tubular nosepiece **108** are sufficient to receive almost the whole length of the mandrel stem so that, when the mandrel stem is fully entered into the bore **106**, the head of the mandrel is spaced above the upper end of the nosepiece by a distance sufficient to allow the detents **84, 86** to close on the mandrel stem below the mandrel head and above the upper end of the cursor tube **110**. The external diameter of the cursor tube **110** is slightly greater than the diameter of the bore through the tubular rivets to be set by the machine, and the deflector **112** reaches a maximum diameter at its lower end which is substantially the same as the diameter of the heads of the rivets to be set. The deflector **112**, by reason of its upwardly tapering shape can act as a cam for opening the pulling jaws. Thus, in the event that the machine is actuated without a supply of rivets or with a rivet absent from the waiting station at an appropriate time, when the piston **94** rises, the deflector **112** pushes its way between the pulling jaws, overcoming the effect of the biasing springs, and opening the jaws in a manner similar to that in which the jaws are normally opened by a rivet, as will become apparent.

Within the bore of the piston rod **102** and attached to the lower end of the tubular nosepiece **108** is a spring detent **114** in the form of a tubular helix formed of spring steel wire and having a curved axis. The upper end of the tubular helix is concentric with the bore of the nosepiece and, due to the curvature of its axis, the lower end of the tubular helix is eccentric to the bore of the nosepiece. Entry of the straight stem of the mandrel into and through the helix causes the curved axis of the tubular helix to become straightened by resiliently deforming the tubular helix. However, due to the resilience of the steel wire tending to return the axis of the tubular helix to the curved condition, the detent exerts a frictional grip on the stem of the mandrel and tends to resist axial movement of the mandrel through the tubular helix.

The stroke length of the lifting piston **94** is such that the nosepiece **108** can be reciprocated between a lowermost position in which it is just below the rivet carrier **22** when the latter is in the waiting position in the riveting head as shown in FIG. **1**, and a raised position in which the nosepiece enters the tubular passageway **37** between the nose jaws **34, 35** of the riveting nose **32** and lifts the nose jaws sufficiently to release them from the constraint of the body **33** so that the nose jaws can open, and the cursor tube **110** projects above the upper ends of the raised nose jaws.

The housing **26** has an opening **120** which registers with a slot **122** in the head member **60** through which the horizontally reciprocable rivet carrier **22** can be reciprocated between the waiting position within the riveting head and a position in which it is retracted from the riveting head to receive a further rivet from the flight **16**.

The double-acting pneumatic jack **24** of the rivet supply means comprises a pneumatic cylinder **124** defining a pneumatic chamber D in which is horizontally reciprocable a piston **126** to which is attached one end of a piston rod **128**. The other end of the piston rod **128** is fixed to a bracket **130** which in turn is secured to the housing **26** so that the piston **126** is immovable relative to the housing. The cylinder **124** is provided with a port at each end for admission of compressed air into the chamber D alternately to the left and right of the piston **126**, as viewed in FIG. **1**, so as to cause reciprocation of the cylinder **124** lengthwise of the fixed piston **126** and its associated piston rod. Fixedly secured to the reciprocable cylinder **124** is one end of an elongate pusher arm **132** which extends parallel to the line of reciprocation of the cylinder **124** and towards the waiting position within the riveting head. The other end of the pusher arm is reduced in transverse width to form a tongue **134** which supports the rivet carrier **22**. The tongue **134** has an elongate slot **136** through which pass two pins **138, 140** which are spaced apart by a distance less than the length of the slot and by which the rivet carrier **22** is slideably secured to the tongue. The arrangement of the slot and pins provides a lost motion connection between the arm **132** and the rivet carrier **22**. The rivet carrier is an assembly comprising a saddle **142** and two rivet gripping fingers **152, 154**. The saddle **142** comprises a pair of upstanding guides **144, 146** disposed on opposite sides of the tongue **134** and in which the pins **138, 140** are threadedly engaged, and a platform **148** which projects beyond the free end of the tongue **134** at a level below the tongue. It will be appreciated that the slot **136** permits the tongue **134** a limited amount of sliding movement lengthwise relative to the saddle **142**. The platform **148** has a slot **150** extending parallel to the tongue **134** from a position beneath the tongue to the free end of the platform remote from the guides of the saddle. The width of the slot **150** is less than the diameter of a rivet head but great enough to receive the stem of the mandrel.

The riveting gripping fingers **152**, **154** are pivotally mounted each on one of the two guides **144**, **146** of the saddle by means of vertical pivot pins **156**, **158** respectively, and are biased by means of a tensioned coil spring **159** secured to each of them to close about a vertical plane which is aligned with the tongue **134** of the pusher arm and above the middle of the slot **150** in the platform **148**.

The fingers **152**, **154** are shaped so as to co-operate when closed to define, with the projecting part of the platform **148**, a cavity **160** in which a rivet can be supported with its head resting on the platform and with the rivet bore disposed above the slot **150** in the platform and with the rivet shank upstanding between the gripping fingers. The cavity **160** is of L-shape and comprises two limbs **162**, **164** which lie at right angles to each other in a horizontal plane and share a common region **166** between them. The limb **162** is aligned with the slotted tongue **134**, and the tongue can slide lengthwise of the limb **162** and through the common region **166** of the cavity when the platform **148** together with the fingers mounted thereon moves lengthwise relative to the pusher arm **132**. The other limb **164** of the L-shaped cavity is in the form of an open-ended aperture extending through the gripping finger **152** into the common region of the cavity. The limb **162** terminates remote from the common region, in a closed end portion below a funnel-shaped guide opening **168** which extends downwardly between the closed fingers from their upper surfaces to the cavity and through which the stem of the mandrel can pass and be guided to enter the bore of a tubular rivet located in the closed end portion of the limb **162**. In the condition of the machine shown in FIGS. **1** and **4**, the closed end portion of limb **162** is occupied by a rivet **180**. A rivet thus positioned in the limb **162** is hereinafter referred to as a "fed rivet".

A tensioned coil spring **170** secured to the pusher arm **132** adjacent to the jack **24** and to a bracket **172** retained by the pivot pins **156**, **158**, resiliently urges the platform **148** towards the pusher arm **132** so that the tongue **134** tends to occupy the common region **166** of the cavity **160** and project into the limb **162** of the cavity.

The reciprocable pusher arm **132** is slideable lengthwise between two vertical guide pillars **174**, **176** which are secured to the bracket **130**.

On retraction of the rivet carrier from the waiting position in the riveting head, (i.e. by operation of the jack **24** to move the pusher arm to the left, as viewed in FIG. **1**) a fed rivet occupying the cavity is left behind at the waiting position, being plucked from the cavity by the stem of the mandrel which at such a time extends through the bore of the rivet in the cavity, the fingers **152**, **154** springing pivotally open to permit withdrawal of the rivet. Eventually the guide **144** of the saddle of the empty rivet carrier **22** moves across the end of the flight **16** and engages the escapement **20**, causing it to pivot and separate the leading rivet **25** from the remaining rivets in the flight. The saddle **142** of the carrier **22** then abuts the guide pillars **174**, **176** just before the pusher arm completes its movement, and movement of the carrier is thereby arrested with the limb **164** of the cavity aligned with the rivet **25** in the flight. The pusher arm continues to move through a short distance, thus causing the tongue **134** to be withdrawn from the limb **162** and the common region of the cavity and thereby opening a way for communication between the limbs **162**, **164**.

A jet **182** is arranged to deliver a blast of compressed air onto the leading rivet in the flight and is directed so that the leading rivet **25** can be blown from the escapement **20** into the aperture which constitutes the limb **164** in the gripping finger **152** so that the rivet will come to lie in the common region **166** of the cavity in front of the tongue **134**.

On subsequently reversing the operation of the jack **24** to move the pusher arm to the right, as viewed in FIG. **1**, lost motion again occurs between the arm and the rivet carrier, with the tongue moving forwardly through the common region **166** into the limb **162**, pushing the rivet in front of it to the closed end portion of the limb **162** below the funnel-shaped guide opening **168** where it becomes a fed rivet. The rivet carrier then begins to move with the pusher arm, disengaging from the escapement **20** which, urged by a tensioned coil spring **184**, returns pivotally to the position shown in FIG. **4** to embrace a further rivet in the flight. The rivet carrier continues to move with the pusher arm, carrying the fed rivet in its cavity, until it enters between the limbs of the yoke **88** and reaches the waiting position as shown in FIG. **4** where it is stopped under the control of the control means.

The riveting machine is powered entirely by pneumatic and electrical power. The electrical power supplied to the machine energises the vibratory bowl feeder **14** and an electronic logical control means, and the power supplied by means of compressed air is used to cause reciprocating movements of the pistons in the pneumatic chambers and to transfer rivets from the flight **16** to the rivet carrier **22**.

The machine is controlled primarily by an operator through the use of a manually operated electrical switch **190** forming part of the electronic control means. Manual operation of the switch **190** initiates performance of a cycle of operations by the machine under the logical control of the control means, commencing with the setting of a rivet and ending with the return of the machine to the condition in which it is again ready to set a rivet.

The condition of the machine at any stage of its operation can be referred to in terms of the positions of the various pistons in the chambers in their respective cylinders, and for brevity the following notation is used hereinafter when describing the operation of the machine: when the pistons **54**, **64** and **94** are at the upper ends of their respective chambers A, B and C, they are said to be in the condition "A+", "B+" and "C+" respectively, and when at the lower ends of their respective chambers, are said to be in the condition "A−", "B−" and "C−" respectively.

Similarly, when the piston **126** is at the left-hand end (as seen in FIG. **1**) of chamber D the condition is said to be "D+" and, conversely, when piston **126** is at the right-hand end of chamber D, the condition is said to be "D−".

The cycle of operations performed by the machine has six phases. The notation indicating the condition of the machine in each of these phases is set out below for convenience of reference, starting with that for the condition illustrated in FIG. **1** in which the machine is ready to set a rivet:

Phase 1: A+, B+, C−, D+.
Phase 2: A−, B+, C−, D+.
Phase 3: A−, B−, C−, D−.

Phase 4: A−, B−, C+, D−.
Phase 5: A−, B−, C−, D−.
Phase 6: A+, B−, C−, D−.

After the sixth phase, the machine returns to the condition of phase 1, thus completing the cycle with a return to the condition in which it is again ready to set a rivet.

The control means is somewhat complex in terms of the number of functional parts, their interconnection and behaviour, but is generally conventional and of a kind well understood in the art of electronics and logical control of mechanical operations. In FIG. 7, therefore, the main parts of the control means are shown as blocks representing major functional units and details of the construction of these functional units are omitted.

The control means comprises six proximity switches indicated in FIG. 7 by the legends A+, A−, C+, C−, B,D+ and B,D−. The proximity switches used in this embodiment are optical switches of the kind having a light-beam emitter and a sensor for the light beam, and are arranged at appropriate positions in the riveting machine to sense positively the conditions of which they bear the notation. Thus, proximity switch A+ responds positively to the condition in which the piston **54** has reached the upper end of chamber A. Proximity switch C− responds positively when piston **94** has reached the lower end of chamber C. A single two-way valve controls the supply of compressed air to both chamber B and chamber D so that the pistons in these chambers operate in parallel and simultaneously. Consequently, a single pair of proximity switches BD+ and BD−, associated with the cylinder **124** and actually sensing only the condition of piston **126** in chamber D, are assumed also to sense accurately the condition of piston **64** in chamber B.

Thus, the six proximity switches monitor the overall condition of the machine and deliver outputs to a logic circuit.

When the outputs of the proximity switches indicate that a given phase of operation has been completed ("YES"), the logic circuit delivers an output via a debounce circuit to a ring counter. In the event that the proximity switches do not deliver the appropriate indications ("NO"), the logic circuit stops the machine from proceeding to a further stage.

The debounce circuit ensures that only a single, pulsed, output signal of a very short duration is passed to the ring counter, thus ensuring that false signals such as might arise from mechanical bouncing of moving parts, are not able to affect the ring counter. With each output signal received from the logic circuit, the ring counter is stepped through one of a plurality of steps in each of which it delivers an output to an appropriate part of a FLIP-FLOP logic circuit to initiate the next action.

Associated with the ring counter are means for resetting the counter to the condition appropriate to the start of the cycle, automatically on first supplying electrical power and manually at the discretion of the machine operator.

The Flip-Flop logic circuit memorises the existing condition of the machine and responds to the outputs of the ring counter by delivering logical outputs in accordance with the desired sequence of operation of the machine. The logical outputs of the Flip-Flop logic circuit are passed via optical isolators to a higher-voltage working part of the control means in which they are amplified by power amplifier circuits to operate three solenoid valves A, C and B,D. Each solenoid valve comprises a solenoid-operated two-way valve for controlling the delivery of compressed air from the compressed air supply to the pneumatic chambers of the machine. Thus solenoid valve A will according to its electrical condition, direct compressed air from the supply to one or other of the ports in the upper and lower ends of chamber A to produce the condition A+ or A− as required.

At the start of the cycle, the rivet **40** is supported at the riveting station by the abutment formed by the closed nose jaws **34, 35** and supports the mandrel **42** in a raised position in which the lower end of the mandrel stem is spaced above the rivet carrier **22**. The piston **126** is in the condition D+ and the rivet carrier **22** is located at the waiting position within the riveting head and holds the fed rivet **180** with its bore aligned with the stem of the mandrel.

The piston **54** is in the condition A+, and the conically apertured member **82** at the upper end of the head member **60** is located with slight clearance below the upper end plate **28**.

The piston **64** is in the condition B+ so that the cone **78** formed by the pulling jaws **48, 50** is wedged into the aperture **80** in member **82** and the pulling jaws are thereby constrained to grip the mandrel stem **44** tightly.

The lifting piston **94** is in the condition C− so that the nosepiece **108** of the lifting piston is just below the platform **148** of the rivet carrier.

A suitably apertured workpiece (not shown) is now brought into position, the head of the mandrel being passed through the aperture in the workpiece and the workpiece is lowered until its lower surface abuts the head of the rivet **40** and the shank of the rivet extends through the aperture of the workpiece. The riveting machine is then actuated by manual operation of the switch **190** to set the rivet.

Actuation of the machine causes it to perform a single cycle of operations, the cycle having six successive phases.

During the first phase of the cycle, the rivet **40** at the setting station is set in the workpiece, and the machine assumes a condition having the notation A−, B+, C−, D+.

Thus, compressed air is admitted to the upper end of chamber A, forcing piston **54** downwardly and thereby causing the head member **60** and the apertured member **82** to force the pulling jaws downwardly in tightly gripping relationship with the mandrel **42**. Thus the mandrel is pulled downwardly so that its head **46** passes entirely through the bore of the rivet **40**, setting the rivet in the workpiece which is then removed, and reaches a position in which the head **46** is below the detents **84, 86** in the riveting nose, while the lower end of the mandrel stem **44**, guided by the funnel shaped opening **168** of the rivet carrier **22**, enters and passes through the bore of the fed rivet **180**, through the slot **150** in the platform **148** and enters into the bore of the cursor tube **110**. The completion of the downward movement of piston **54** actuates the switch A− of the control circuit. This completes the first phase of the cycle, and the machine is ready to commence the second phase.

During the second phase, the condition of the machine changes to the condition shown in FIG. 2 and having the notation A−, B−, C−, D−, causing the rivet carrier to be retracted from the waiting position in the riveting head and releasing the pulling jaws from the condition in which they are locked together and tightly gripping the mandrel.

Thus, the piston **64** is moved to the lower end of chamber B, moving the pulling jaws downwardly relative to the head member **60** and the conically apertured member **82** thereof, thereby withdrawing the pulling jaws from the aperture **80**. The pulling jaws then remain in a closed relationship by virtue of the spring bias applied to them.

Simultaneously, the cylinder **124** moves to the left (as viewed in FIG. **1**) bringing the fixed piston therein to the condition D− and retracting the rivet carrier **22** from the riveting head. The fed rivet **180**, which until this time has been held in the rivet carrier, and through the bore of which the mandrel stem now extends, is thus plucked by the mandrel stem from between the fingers **152**, **154** as the carrier retracts, and is then free to slide down the stem of the mandrel until it reaches the upper end of the cursor tube **110** into which the mandrel stem extends. Thus, the fingers are sprung apart against the bias of the tensioned coil spring **159** leaving the fed rivet threaded on the stem of the mandrel which itself is supported against lateral movement by the cursor tube and the nose jaws.

As previously explained, retraction of the rivet carrier operates the escapement causing the leading rivet **25** in the flight to be separated from the other rivets therein.

The second phase of the cycle ends with actuation of the switch BD−, and the machine is then ready for the third phase of the cycle.

During the third phase, the condition of the machine changes so as to assume the condition shown in FIG. **3** and having the notation A−, B−, C+, D−, causing the fed rivet **180** to be lifted upwardly along the mandrel to the riveting station so that the rivet **180** comes to occupy the position formerly occupied by the rivet **40** which has by now been set and become part of the workpiece.

Thus, compressed air is admitted to chamber C below the piston **94**, causing the piston **94** to rise and with it the piston rod **102** with its nosepiece **108**. As the rising nosepiece and piston rod surround the mandrel stem, the stem enters progressively into the bore of the nosepiece until it encounters the spring detent **114** which presents some resistance to entry of the stem. When this happens, the mandrel then begins to rise with the rising nosepiece and continues to do so until the head of the mandrel engages the underside of the detents **84**, **86** which resiliently resist deflection by the head of the mandrel. The resistance of the detents **84**, **86** in the nose jaws is greater than that of the spring detent **114** to entry of the mandrel stem so that the rise of the mandrel is arrested while the piston **94** continues to rise. The resistance of the spring detent **114** is therefore overcome and the mandrel stem slides through the detent, straightening the curvature of its axis, and enters further into the bore **106**. The rising nosepiece **108** therefore lifts the fed rivet **180** along the mandrel stem, causing the spring biased pulling jaws to open and allow the rivet and then the nosepiece and eventually the piston rod **102** to pass between them, until the rivet comes into engagement with the head of the mandrel. The force required to cause the head of the mandrel to enter the rivet bore is considerably greater than that required to overcome the resistance of the detents **84**, **86**, and consequently the detents **84**, **86** yield, allowing the rising nosepiece to lift the rivet **180**, and with it the mandrel, past the detents **84**, **86** and into engagement with the constriction in the passageway **116** between the nose jaws. As the rivet continues to rise, the nose jaws **34**, **35** are lifted relative to the body **33** until they are able to part and allow the mandrel head and the rivet **180** through the constriction to a position above the nose jaws. Once the rivet **180** has passed the constriction, the jaw-closing spring **36** returns the nose jaws downwardly into the tubular body **33** whereby they are constrained to close about the cursor tube beneath the head of the rivet **180** which is now located at the setting station, occupying the position formerly occupied by the now set rivet **40**.

At this point it is appropriate to explain that, but for the frictional engagement between the spring detent **114** and the stem of the mandrel, the inertia imparted to the rivet **180** and the mandrel by the rise of the lifting piston would, when the nose jaws yield to passage of the rivet, cause the mandrel and possibly the rivet also to continue to rise even after the lifting piston had reached the end of its upward stroke. However, the detent **114** exerts sufficient frictional grip on the mandrel to prevent it being shot upwardly in this way to any appreciable extent. To the extent that this phenomenon may occur nevertheless, it is corrected in the fourth phase of the cycle as will become apparent.

The third phase of the cycle ends when the lifting piston **94** reaches the upper end of its stroke in chamber C, as shown in FIG. **3**, with actuation of the switch C+ by the rising nosepiece **108**. The rise of piston **94** is arrested and the fourth phase of the cycle is then entered.

In the fourth phase, the lifting piston descends, bringing the machine to the condition A−, B−, C−, D−, and allowing the pulling jaws to close about the mandrel stem by virtue of the spring bias applied to them, and simultaneously the rivet **25** is transferred from the escapement into the rivet carrier.

Thus, air is supplied to the jet **182** and to the upper end of chamber C through the port **104**, depressing the piston **94** and thus lowering the piston rod **102** and nosepiece. If, during the third phase, the mandrel was shot upwardly so that the mandrel head was spaced above the upper end of the rivet **180**, the frictional engagement of the mandrel stem by the spring detent **114** in the descending nosepiece now enables the mandrel to be dragged downwardly until its head becomes seated on the upper end of the rivet **180**, where it stops while the nosepiece continues to descend until it is below the waiting position into which the rivet carrier is movable. The blast of air emerging from the jet **182** blows the rivet **25** from the escapement into the L-shaped cavity in the rivet carrier by way of the entry passageway **164**, so that the rivet comes to occupy the common region **166** of the cavity.

Completion of the descent of piston **94** causes the delivery of air to the jet **182** to cease and initiates the fifth phase of the cycle.

During the fifth phase, the pulling head rises in the housing, lifting the pulling jaws in their unlocked condition upwardly along the stem of the mandrel, and bringing the conically apertured member **82** substantially up to the upper end plate **28** of the housing, so that the machine assumes the condition A+, B−, C−, D−.

Thus air is admitted to the chamber A below piston **54** causing the piston to rise and lift with it the pulling head in which piston **64** remains at the lower end of chamber B. In this condition the pulling jaws do not grip the mandrel sufficiently tightly to overcome the frictional engagement of the mandrel stem by the detents **84, 86** and so do not cause it to move upwardly. On reaching the upper end of its stroke, the moving pulling head actuates the switch A+ which terminates the fifth phase and the sixth phase of the cycle begins.

During the sixth phase, the rivet carrier carries the rivet **25** away from the flight and into the waiting position in the riveting head, and simultaneously the pulling jaws are caused to grip the mandrel stem tightly, the machine assuming the condition A+, B+, C−, D+.

Thus, compressed air is admitted to the right hand end of chamber D, causing the cylinder **124** to move to the right and advance the rivet carrier **22** into the riveting head. As previously explained, as soon as the rivet carrier is moved away from the guide pillars **174, 176,** the fed rivet **25** is moved from the common region of the cavity up to the closed end of the limb **162** and beneath the funnel-shaped guide opening **168,** and on reaching the waiting position is held below and aligned with the stem of the mandrel.

Simultaneously air is admitted to the chamber B below piston **64,** causing piston **64** to rise relative to the head member **60** so that the pulling jaws are raised to drive the cone **78** wedgingly into the conical aperture **80** and the jaws are thereby constrained to grip the mandrel tightly.

Switch B,D+ is actuated by the completion of the movement to the right of the cylinder **124** and the air supply to chamber B is cut off so that the machine then becomes quiescent in the condition A+, B+, C−, D+. However, the pulling jaws remain tightly gripping the mandrel stem by reason of the constraint applied to them by the conically apertured member **82,** and thus the machine ends the cycle in a condition ready to set the rivet **180** upon next actuation of the manually controlled switch **190** by the operator.

We claim:

1. A blind riveting machine comprising abutment means for supporting a rivet during a rivet-setting operation, a mandrel having a stem and an enlarged head at one end of the stem, gripping and pulling means for releasably gripping the stem of the mandrel and moving the mandrel rearwardly relative to the abutment means through a stroke of sufficient length to pull the head of the mandrel entirely through the bore of a tubular rivet supported by the abutment means and thereby set the rivet and thereafter to release the mandrel to allow a further rivet to pass along the stem of the mandrel towards the head, and reciprocable means for advancing a further rivet along the mandrel to the setting station after the setting of the first mentioned rivet and the release of the mandrel, and moving the mandrel forwardly to a position in which the head of the mandrel is spaced forwardly of the abutment means by a distance which is at least sufficient to accommodate the further rivet to be set and then moving the mandrel rearwardly so that the head engages the further rivet at the setting station before the gripping and pulling means again grips the mandrel stem.

2. A blind riveting machine comprising separable nose jaws which can be closed to provide an abutment for supporting a rivet at a setting station, pulling means for releasably engaging and pulling a mandrel having a head and a stem so as to draw the head of the mandrel through the bore of a tubular rivet supported by the abutment and thereby set the rivet, reciprocatory means for moving a further rivet forwardly along the stem of the mandrel to the setting station after the setting of the first mentioned rivet, past the released pulling means and the separated nose jaws, and thereby moving the mandrel to a position in which the head of the mandrel is spaced forwardly of the abutment by a distance at least sufficient to accommodate the further rivet at the setting station, the reciprocatory means including overridable means for engaging the mandrel before the pulling means again engages and pulls the mandrel, whereby, on the return stroke of the reciprocatory means the mandrel may be moved rearwardly to a position in which the head of the mandrel is spaced forwardly of the abutment means by a distance not exceeding the length of stroke of the pulling means.

3. A blind riveting machine according to claim **2,** wherein the overridable means for engaging the mandrel comprises resilient means for frictionally engaging a mandrel, and the nose jaws include yieldable means for resisting forward movement of the mandrel whereby a mandrel is urged into engagement with the overridable means when the reciprocatory means moves forwardly to move a further rivet to the setting station.

4. A blind riveting machine comprising abutment means for supporting a rivet during a rivet-setting operation, a mandrel having a stem and an enlarged head at one end of the stem, pulling means for releasably engaging and pulling the mandrel rearwardly relative to the abutment means through a stroke of sufficient length to pull the head of the mandrel entirely through the bore of a tubular rivet supported by the abutment means and thereby set the rivet and thereafter to release the mandrel to allow a further rivet to pass along the stem of the mandrel towards the head, and reciprocable means for moving a further rivet along the stem of the mandrel to the setting station after the setting of the first mentioned rivet and thereby moving the mandrel forwardly to a position in which the head of the mandrel is spaced forwardly of the abutment by a distance at least sufficient to accommodate the further rivet at the setting station, the reciprocable means including overridable detent means for engaging the mandrel whereby, on the return stroke of the reciprocable means, the mandrel may, if so positioned that the head of the mandrel is spaced forwardly of the abutment means by a distance greater than the length of the said further rivet, be moved rearwardly to close the distance between the mandrel head and the abutment.

5. A blind riveting machine according to claim **4,** wherein the overridable detent means is adapted to frictionally engage the mandrel so that the mandrel can be moved with and by the reciprocable member, the frictional engagement being capable of being overridden by abutment of the mandrel head with a rivet supported by the abutment means.

6. A blind riveting machine according to claim **4,** wherein the detent means comprises resiliently deformable means adapted and arranged to frictionally hold the mandrel when the mandrel and the detent means are forced into mutual engagement.

7. A blind riveting machine according to either of claims **5** or **6,** wherein the detent means comprises a tube formed of resiliently deformable material and having a curved axis.

8. A blind riveting machine according to claim **1,** wherein the tube is formed of helically wound wire.

9. A blind riveting machine according to any of claims **4, 5,** or **6,** including yieldable means for resisting forward movement of the mandrel so as to cause the mandrel to be urged into engagement with the detent means.

10. A blind riveting machine according to claim **9**, wherein the yieldable means comprises at least one yieldable detent arranged to resist passage of the head of the mandrel from a position rearwardly of the abutment means to a position forwardly of the abutment means.

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